The Nature of Streams

Streams, like men, go through a progressive life cycle from youth to maturity. While year-to-year changes can be observed in man, such short-term changes in a stream are not always apparent. As a case in point, consider a small stream flowing through a country village. The stream and its banks have always been a fixed part of the landscape. Suddenly, a bank that has shown no sign of distress since the village was settled sloughs off. The local community wonders what undetected course of events triggered the bank failure and what terrible consequences will follow. What the townspeople do not realize is that the stream is either moving into another stage of its natural life cycle or is responding to some impact caused by man's activity. Prior to developing an understanding of streambank erosion and failure, we must first understand the nature of a stream and its bed and banks. The reader should note here that there is an important conceptual difference between streambank erosion and failure. *Erosion* is the removal of soil particles from a bank surface primarily due to water action. *Failure* is the collapse or slippage of a large mass of bank material into the stream.

A stream should be considered as a delicately balanced mechanism that is gradually maturing. Naturally, landowners and local governments would like to find a stream in a well-balanced condition with smooth, gentle bends, well-vegetated banks free from erosion or failure, and a channel bed that is neither scouring nor building up with sediment. Unfortunately, this pleasant picture is often only a passing scene. A stream, like the plants and animals that live near the stream, must continually adjust to new impacts in order to maintain its balance. These impacts are not only caused by man's activities but are also natural in origin resulting from the maturing process of the stream. When the balance is upset, the stream will respond by some compensating action to bring the stream system back into balance. The most common compensating actions are streambank erosion and bed scour or buildup.

As examples of situations where a stream is thrown out of balance, consider the following common occurrences:

a. A dead tree topples into a small stream. Much of the water flow begins to be diverted by the tree against the opposite bank. At the same time water still moving near the tree slows down and deposits sediment. As sediment builds up around the tree, the velocity of the diverted water increases. Eventually the opposite bank begins to seriously erode and a bar builds up over the fallen tree. Thus, the response of the stream to the fallen tree was realignment of its channel around the tree and erosion of the bank opposite the tree.

b. To increase his planted acreage, a farmer clears off a greenbelt parallel to the stream flowing through his farm. He is then able to plow to the edge of top bank. Unfortunately, the farmer does not realize that rainfall runoff will be channeled down the bank face. As the soil holding the shrubs and grass in place on the bank is slowly eroded away, the natural vegetation is lost, leaving a relatively smooth slope. The stream responds to this loss of "natural roughness" by seriously eroding the surface of the bank during the next flood. After several floods, the farmer not only loses the land originally covered by the greenbelt, but he also loses many valuable acres landward of the greenbelt.

c. A real estate developer is clearing land near a stream. Although many of the large trees are harvested and taken to a saw mill, much of the brush and scrub timber is pushed by bulldozers into the stream channel to be carried away by the next high water. During the next flood, the refuse is indeed carried downstream. This debris in combination with some dead trees that have fallen into the stream form several very large brush and timber piles. When low water conditions return, a few of the piles are positioned such that the streamflow is deflected against the bank toes. As the lower banks are eroded away, the upper banks collapse. Thus, downstream landowners begin losing land along the stream as a consequence of improper land clearing techniques upstream.

d. Rapid urbanization of a watershed's upstream area has resulted in paving and roofing much of the ground surface area originally available for rainfall infiltration. No provisions were made by urban planners to control the runoff rate. As a result, the downstream flow during storms is greatly increased. The response of the stream is to enlarge its channel by bank erosion and bed scour to accommodate the increased flow. As in the case of the real estate development, downstream landowners again lose acreage along the stream because planners did not properly assess the impact of an upstream activity on downstream flow conditions.

The cases discussed above are only a few that could occur when a stream is forced to respond to an impact that is not part of the stream's natural development. Landowners and local governments must realize that most streams are in a continuing state of adjustment (although possibly changing very slowly as compared with the human lifespan) as the stream attempts to compensate for an imbalance at one location by making changes at other locations. Further, when some form of bank protection is put into place the stream will respond to this change. The response may be insignificant or it could be as serious as transferring the erosion or failure problem to a bank downstream. Thus, protection of a bank should be taken seriously, not only in light of successfully protecting the bank, but also considering the impact of the bank protection on the entire stream system.

STREAMBEDS

One of the characteristics of a well-balanced stream is that the elevation of its bed remains relatively constant. If an imbalanced condition develops, the stream could respond in one of two ways: by scouring out its bed or by depositing excess sediment carried by the stream onto the bed. Either condition can lead to problems for the landowner or local government.

The streambed acts as a foundation for its banks. If streamflow scours out the bed and in the process erodes the bank toe, then the upper bank may no longer have any support, and failure can follow. Alternatively, when a stream is not able to carry its sediment load, material will be deposited on the streambed. As a result, the elevation of the bed will rise, thus reducing the size of the channel. When the next flood comes, the stream will try to enlarge itself to its original size in order to carry the flood flow. As the enlargement process occurs, not only will the bed be scoured out, but both banks may be eroded as well. The most important consideration here is that if the bed of a stream is rising or falling, the investment of time and money into a streambank protection project is questionable because the problem may lie with the bed and not the bank.

Prior to considering construction of a project to protect a streambank, the landowner or local government should first attempt to determine if the streambed is in balance. Typical signs that the bed is not in balance are:

- Rushing water in an otherwise tranquil stream
- Waterfalls (often called headcuts)

- A noticeable increase in channel width caused by caving along both banks
- Continued raising or lowering of the streambed. This may be observed as a change in bed elevation around bridge piers, dock pilings, etc.

If there is any reason to believe that the streambed in the vicinity of a proposed streambank protection project is not in balance, then professional assistance should be sought before further project planning takes place. If the bed is not in balance, a project should be considered only if the bed elevation can be controlled or if future changes in the bed elevation are anticipated to be minor.

Lowering of the bed elevation around bridge piers may indicate that the streambed is not in balance.

STREAMBANKS

When a bank comes under attack, its ability to resist the attack depends in part on the kind of soil materials found on the surface of and in the bank. These soils are grouped into five major types based on particle size and whether or not the particles tend to stick together (known as cohesion):

Soil Type	*Particle Size Range*	*Cohesive*
Cobbles	greater than 3 inches	no
Gravel	1/4 to 3 inches	no
Sand	microscopic to 1/4 inch	no
Silt	microscopic	no
Clay	microscopic	yes

Only cobbles, gravel, and sand particles can be directly observed by the unaided human eye. Microscopic soil particles can be identified by their cohesive properties. Because clay is cohesive it can be molded into a ball that will not crumble. Silt is not cohesive and will crumble when rolled into a ball.

The soil composition of a streambank can range from simple to very complicated. The simplest case would be a bank where only one soil type is found. At the other extreme, the bank could be an indistinguishable mixture of cobbles, gravel, sand, silt, and clay that would require a laboratory analysis to determine the exact composition. Natural streambanks are often stratified, that is several soil types or mixtures of soil types are found in layers. The break between the layers can be seen on a bank face as a change in color or texture of the soils material if the bank has not become covered by a layer of sediment that has dropped out of the passing streamflow.